# CHAPTER 7: BOILER MAINTENANCE Part 2

## BOILER FIRE SIDE MAINTENANCE

Boilers that have been out of service for extended periods must also be maintained externally, specifically on the flue gas side.

If a boiler is shut down for longer than a month, or during the winter months, depending on the type of boiler and fuel, the presence of ash and refractory material contaminated with corrosive elements can be addressed.

In some cases, these elements can be removed by washing the boiler with alkaline water (a small amount of soda ash in clean, hot water).

Do not attempt to use lime, as it is corrosive to iron in the presence of moisture. The boiler must be dried using indirect heat (electric or external steam), as igniting flames inside a "wet" boiler will cause corrosion.

**The washed boiler must be dried immediately, avoiding keeping it "wet."**

**The drying time is crucial; it takes weeks, not days, because the water has penetrated the refractory material and is difficult to dry.**

**The boiler temperature must be raised to about 80°C-100°C (212°F) for several days, quickly (after a quick wash), since corrosion will always occur if there is moisture or water from the wash itself** (this can be done with the boiler empty, with hot air, or flooded with treated water).

In winter months (for boilers exposed to the elements), it is necessary to maintain a temperature of a certain number of degrees Celsius (based on the wet-bulb temperature) continuously, using indirect heating (electric or external steam).

Never introduce steam into the boiler, as condensed steam is corrosive, even with chemical preservatives.

One technique could be to circulate the boiler water through an external heater or a heating tank, ensuring that the treated water from the boiler is always circulated, without coming into contact with air or losing water (under any circumstances).

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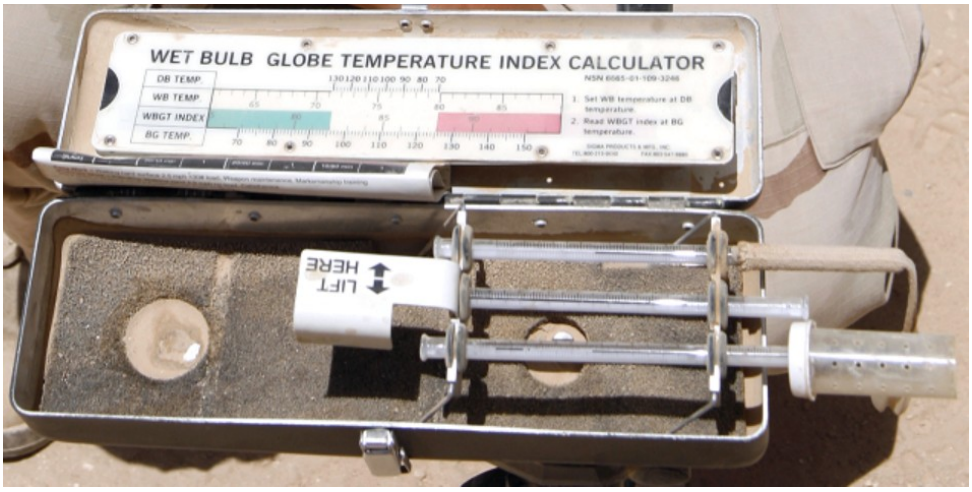



(WET BULB TEMPERATURE, https://en.wikipedia.org/wiki/Wet-bulb_globe_temperature#/media/File:Analog_WBGT_meter.jpg)

**One of the most common causes of corrosion in boilers that are not in use are seals failure, the loss of the neck valves and the steam distributor, which allows steam from other boilers in operation to enter.** This steam, when it condenses on the top of the boiler, causes corrosion by displacing the treated water with condensate, which is corrosive.

Condensation from the roof or rainwater entering through the exterior of the boiler, such as the cover or casing, is also very harmful.

To prevent humid air from entering the boiler's combustion chamber, once it is dry and under some maintenance heating, close all air inlets and especially install a canvas or sheet metal "bonnet" to cover the chimney.

**In some boilers, not only does the draft created by the chimney bring moisture into the boiler, but rainwater can also enter through the chimney itself,** or the draft can reverse when the boiler is colder than the surrounding environment (allowing moisture to enter).

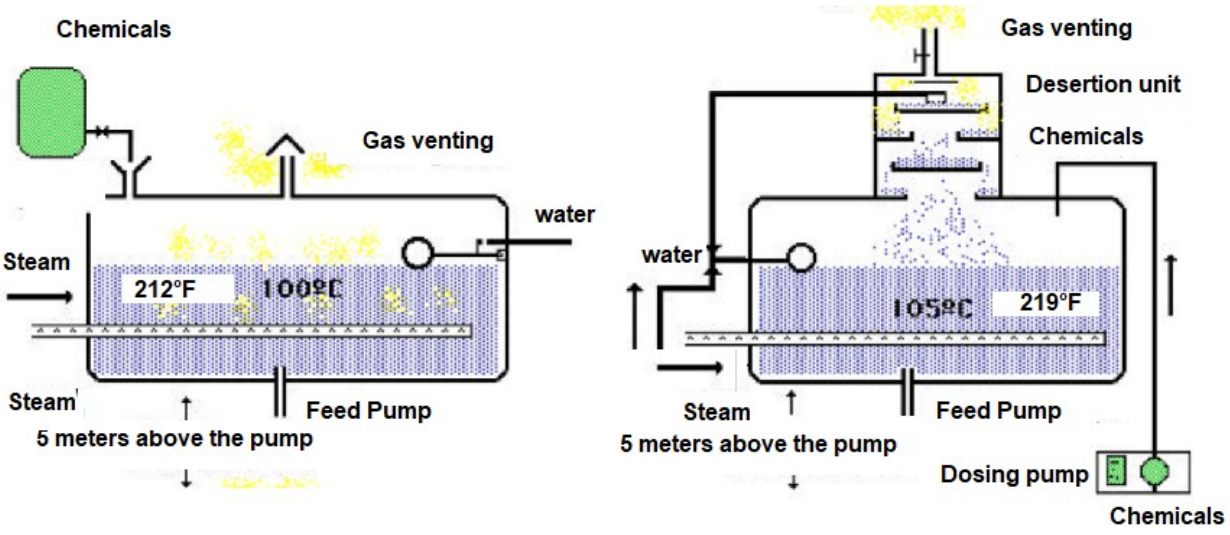
## WATER TREATMENT CHEMICAL DOSING

It is evident that the dosing of chemicals for water treatment, specifically for internal boiler treatment, is generally more effective

through continuous dosing than by adding them in batches or buckets (all at once per day).

**Often, attempting to add all the chemicals needed for 24 hours at once to the feed tank causes significant harm, as it can lead to overdosing.**

This can alter the water's surface properties, causing carryover or, worse, priming (a massive carryover of water that leaves the heat exchange surfaces uncooled and can cause water hammer in the steam lines).




TWO WAYS TO REMOVE OXYGEN FROM FEED WATER

**It is also important to consider whether the chemicals will cause damage to the feed pump system.** This includes abrasion from precipitates, attacks on the pump brass, attacks on mechanical seals, etc., since abrasion is the accumulation of mechanical and chemical effects.

For example, the use of **trisodium phosphate** in the feed tank can affect the pumps, as its precipitation, combined with water hardness, can cause erosion (it is usually injected directly into the boiler drum at high pressure using a high-pressure dosing pump).

Similarly, the introduction of **substances containing ammonia** in large quantities can damage the pump brass (especially the wear rings and bronze impellers).

The use of **polyphosphates** is more advisable to avoid the use of **orthophosphates (trisodium phosphate, disodium phosphate, etc.)**, as these do not precipitate as orthophosphates until they are inside the boiler.

Dosing pumps can be of the mechanical variable displacement type (mechanically driven by a piston or diaphragm) or the peristaltic magnetic type (using an electromagnet driven by an electronic circuit that generates a variable-frequency magnetic field in a coil, which in turn drives a diaphragm; the frequency determines the volume variation based on the number of strokes per minute).

**Both pumping systems have flow direction, suction, and exhaust control valves, which tend to become clogged with deposits if soft water is not used to dissolve the chemicals.**

The dissolved chemicals must be kept homogeneous using an agitator and should be introduced, after being dissolved, cooked, etc., through a funnel with a filter to prevent clogging of the pump filter or valves.

When using oxygen scavengers, it's important to note that continuous agitation can be counterproductive, as it introduces air (oxygen into the solution) which reduces the sequestering agent's effectiveness inside the boiler (because it has been consumed).

**It's good practice to perform a chemical cleaning of the water feed pump, its suction filter, and the system once a month using 5% hydrochloric acid in a closed circuit for a few minutes, followed by a thorough flush with clean water (taking care to prevent any acidic solution from entering the boiler).**

Generally, it's advisable to prepare the product in the dosing pump tank for each shift (6 or 8 hours), periodically cleaning the tank of any deposits that may accumulate at the bottom.

**Dosing pumps should not be operated without product solution in the tank, as running dry can damage the diaphragms or pistons**.

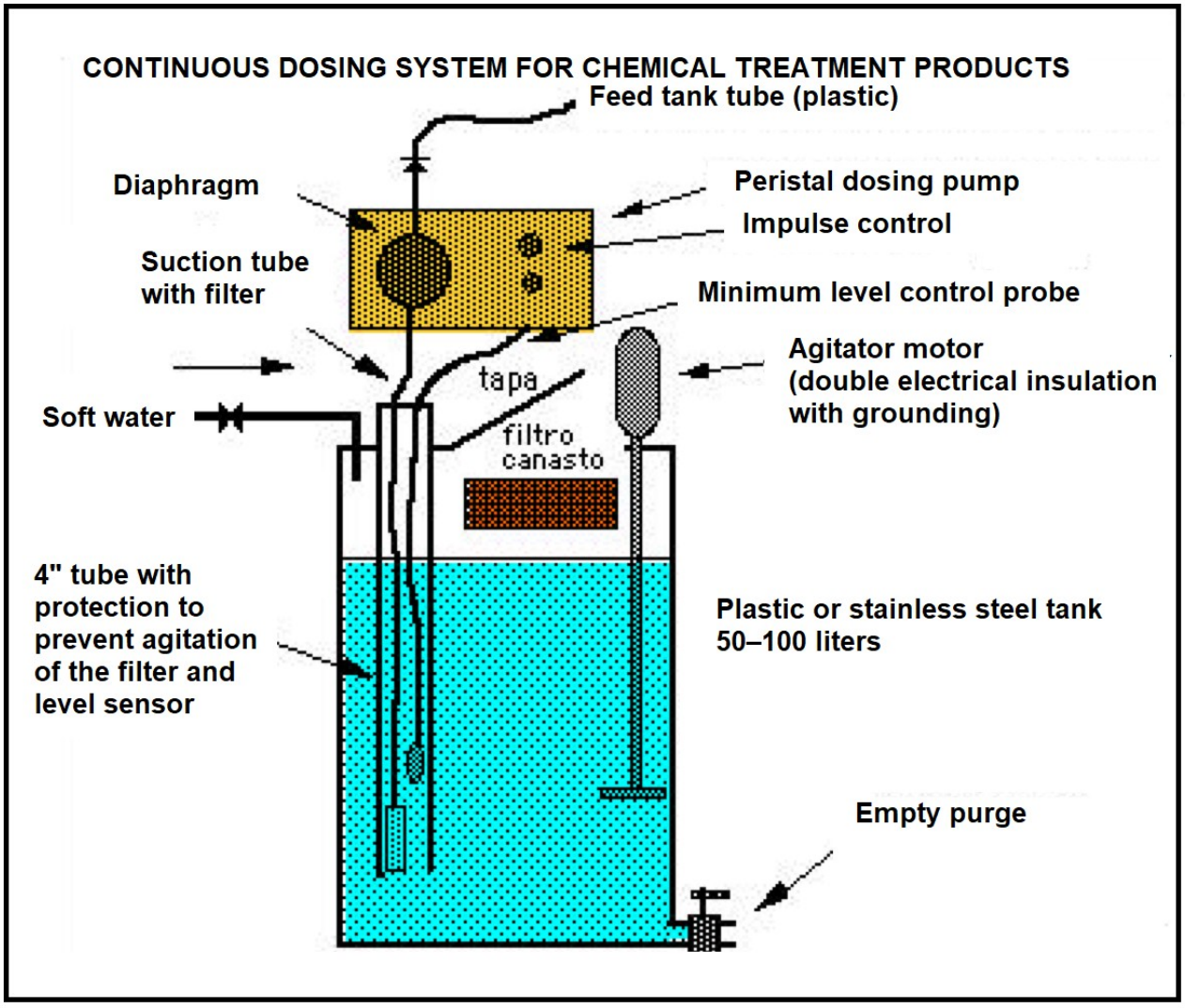
Therefore, they should be equipped with a minimum level float switch that stops the pump when there is no more solution to submerge the filter.

The tank must be made of an inert material (industrial plastic, stainless steel, etc.) that is easy to clean. The agitator must be mechanical, since agitation with air introduces oxygen into the system (which must be removed at all times).

Regarding agitation, it should not be continuous, as this introduces air into the solution (with the same problem as agitation with air).

**In the following sketch**, we have drawn a continuous dosing system with an electronically controlled peristaltic pump. We have detailed several elements to avoid maintenance and operational problems: a generously sized tank, a lid that opens halfway across the tank to allow both the addition of products through a mesh filter and easy cleaning of the tank's interior.

A 4" tube made of product-inert material houses the plastic suction tube and probe to prevent the pump from running dry (without solution), thus avoiding agitation and entanglement with the stirrer.


CONTINUOUS DOSING SYSTEM FOR CHEMICAL TREATMENT PRODUCTS
Feed tank tube (plastic)
Diaphragm
Peristal dosing pump
Impulse control
Suction tube with filter
Minimum level control probe
Agitator motor (double electrical insulation with grounding)
tapa
Soft water
filtro canasto
4" tube with protection to prevent agitation of the filter and level sensor
Plastic or stainless steel tank 50–100 liters
Empty purge

CONTINUOUS DOSING SYSTEM FOR CHEMICAL TREATMENT PRODUCTS

A drain valve and a soft water feed are also essential (otherwise, the filter and pump valves will become scaled, or sediment will quickly

clog the filter). The tank must not be corroded by the chemicals. **Experience indicates that each shift (6 or 8 hours) should prepare its own chemical treatment dosage for the boiler feedwater, distributing responsibilities and ensuring proper preparation of the chemicals (pre-dissolving, heating if necessary, filtering upon addition, etc.).**

These pumps and their suction system should be periodically washed with a 3% to 5% hydrochloric acid solution for a few minutes, followed by a thorough rinse before putting them back into service. A circuit can be established between a 5-liter plastic container into which the pump's suction and discharge lines are immersed. The pump is then run for 10 to 20 minutes, and then a thorough rinse is performed.

Although for corrective dosing in the form of a "shock," it is advisable to have a valve on the feed pump filter cap.

This allows for drawing from a bucket of dissolved chemicals to be introduced in a "sudden" or "shock" manner for instant corrections or the introduction of preservatives with the boiler stopped or about to stop, although if it is stopped, it is advisable to vaporize a little.

## BOILER WATER SAMPLING:

**The boiler water for analysis must be representative of the water inside the boiler.**

I believe that purge water is not the most suitable, as it contains sludge that interferes with the analysis results. The tests will focus on dissolved salts (pH, TDS, alkalinity, chlorides, phosphates, sulfites, etc.). Suspended solids will also be monitored.

We will consider the case of low-pressure boilers (up to 15 kg/cm², 113 PSI). In these cases, the water extracted from the continuous blowdown can be suitable, provided the blowdown has a heat recovery unit to prevent flash steam. Flash steam will concentrate the sample, distorting the analysis results.

If the continuous blowdown does not have a heat recovery unit, it is advisable to use a chiller (refrigerated coil) to cool the sample below

100°C (212°F) to prevent concentration.

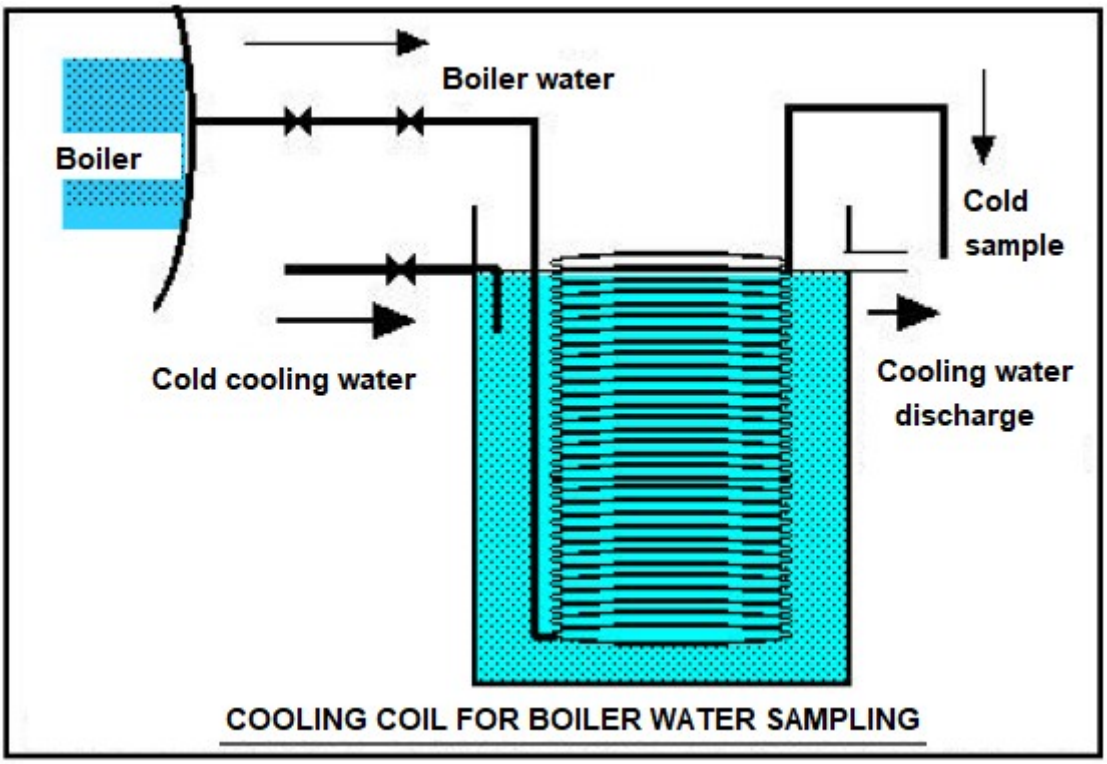
The sample should be taken from the continuous purge, as low-pressure boilers generally do not have a direct connection for sampling.

Just as cooling the sample in a coil is important, it is crucial that the sample be placed in a plastic "bottle," then tightly sealed to prevent air from entering, and unaffected by temperatura. Some plastic bottles are suitable, but if using metal-stainless steel bottles, be careful that the pressure generated does not cause burns or crushing upon cooling, as plastic bottles will only "swell" and shrink upon cooling, adapting to the internal liquid.

This sample should be cooled to room temperature and analyzed as soon as possible, thus avoiding alteration of the chemical values (due to contact with air).

Run the sample water through the coil before turning on the cooling water or filling the cooling water container. Rinse the "bottle" that will hold the sample several times.

Once full, seal the "bottle" tightly with the cap and place it to cool in a container or under running water, taking care that no external water enters, since cooling the "bottle" will create a vacuum that can cause water or air to enter (the advantage of the plastic "bottle" is that it will shrink and the vacuum will be minimal).




COOLING COIL FOR BOILER WATER SAMPLING

The coil can be a stainless steel or copper pipe, from 1/4" to 3/8", generally a diameter of 150 mm to 200 mm per turn is sufficient, generally achieving with about 15 to 20 turns, putting a shut-off valve against the boiler and a globe valve to regulate the flow of the sample to a value that the coil can cool.

## 3-Inspections:

**The boiler should be inspected internally once or twice a year.**

These inspections will allow for the detection of scale, sludge, and corrosion.

All internal parts subjected to mechanical stress (welds, stays, fluid inlets and outlets, etc.) and pressure (plates, casing, tubes, etc.) should be inspected. Stays tend to corrode at the weld in the hottest area (due to the thermal differential).

Steam zones can corrode, especially during periods of shutdown (boilers remain full to their normal level, allowing air to enter, the oxygen of which attacks the damp metal through partial condensation).

Typically, the tubes become pitted (perforated by oxygen when boilers are shut down without proper treatment).

## SWIMMING POOLS BOILERS

**Boilers used to heat swimming pools are at high risk of corrosion if contaminated with pool water** (chloride ions attack metal just like oxygen), making it highly advisable to perform internal chemical and visual checks of the boiler as frequently as possible, given that pool heat exchangers tend to develop leaks in a short time.

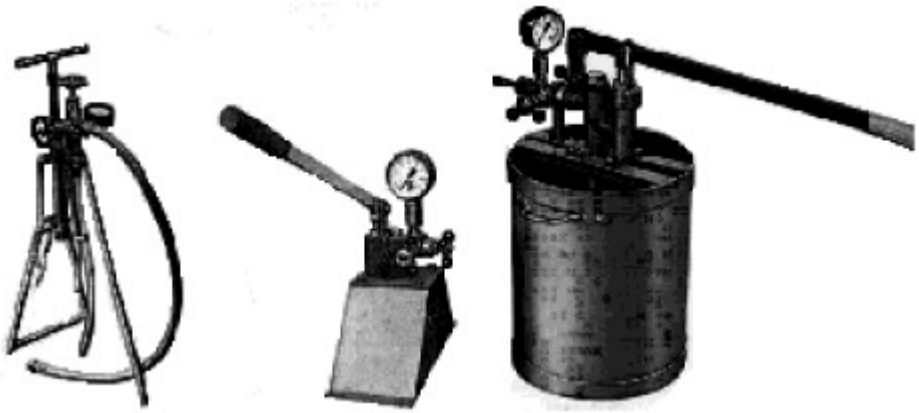
The use of hypochlorite in the water that feeds the boiler is a source of corrosion, both cold and hot; chlorine must be removed by means of activated carbon filters or by means of "sequestration" by excess

sodium sulfites in the feed tank and the boiler.

## HYDRAULIC TESTING

**We must define a hydraulic test as; completely filling the boiler with cold water, removing the air from inside through the atmospheric tap, and then slowly injecting pressurized water until a certain pressure is reached.**

Test pressure which must be predetermined and the pressure gauges used must be very precise.



HIDRAULIC TEST HAND PRESSURE PUMPS

This pressure, as long as it remains below the "ringing" pressure (the maximum design pressure at which the last safety valve should open), does not harm the boiler.

However, if we increase the pressure above the maximum design pressure, we are subjecting the boiler material to "elastic stretching" within a range where this stretching is reversible (returning to its original shape once the pressure is released).

**But this elastic "deformation" can become permanent if we exceed the maximum permissible pressure or if we leave the boiler pressurized for too long** (if a spring is left compressed for a long time, it will not return to its original shape).

**From this, we must conclude that hydraulic tests should not be performed unnecessarily at high pressures (up to 1.5 times the design pressure in most cases for strength and leak testing).**

And for those cases where we only want to know about leaks: that

there are no leaks from the pressure vessel (or valves, levels, etc.), it is sufficient to increase the pressure to the normal working pressure.

This hydraulic test can be called a leak test and can be performed as many times as necessary (always increasing the pressure slowly).

The hydraulic resistance test requires sealing all water and steam inlets and outlets, disconnecting all controls that could be affected by high pressure, and using a hand pump (or pneumatic or electric positive displacement pump with a relief valve) for hydraulic testing.

The boiler is filled with cold water (at room temperature, generally no less than 25°C (77°F), with the boiler also at room temperature, less than 50°C (122°F)).

This is to minimize variations in the standard pressure gauge due to pressure fluctuations caused by changes in the water temperature inside the boiler or the boiler itself. Changes in volume affect the pressure as the temperature rises or falls (due to the difference in the coefficient of expansion between water and the boiler metal).

This is something we are all used to seeing when we turn on the boiler with cold water at the normal level; we see that as the temperature increases, the water expands more and the pressure rises.

The pressure level is very important, and even very small temperature variations caused by air currents in the boiler room, often due to the natural draft of the boiler's chimney (which, depending on whether it draws in hot or cold air, can alter the pressure gauge reading if the test is delayed longer than necessary), can affect the pressure gauge reading.

**First, completely bleed the air through the atmospheric valve, and then gently and carefully increase the pressure with the pump, in stages, starting from a predetermined pressure.**

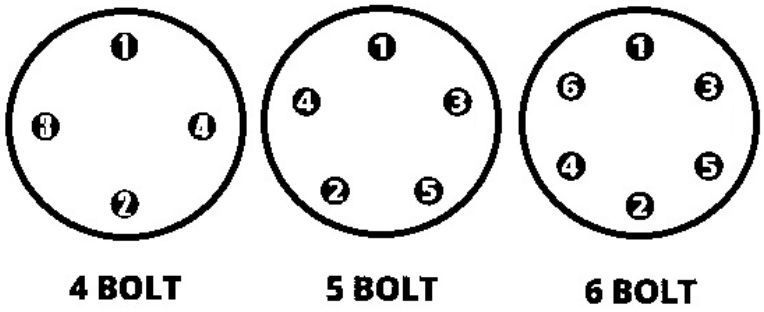
**BEFORE INCREASING PRESSURE, ENSURE THAT NO AIR REMAINS TRAPPED INSIDE THE BOILER. THIS WILL NOT ONLY GIVE A FALSE READING ON THE PRESSURE GAUGE, BUT IF A**

**BREATH OCCURS, THE ELASTIC EFFECT OF THE AIR CAN CAUSE THE EXPANSION OF THE WATER OR PART OF THE BOILER, WHICH IS VERY DANGEROUS.**

**Careful attention must be paid to the maximum pressure and the accuracy of the pressure gauge, as there will be no limit to the maximum pressure except that established and monitored by the gauge.**

**Once the pressure test is complete, slowly reduce the pressure to avoid structural deformation.**

After the test, it is advisable to **replace the seals on the manholes, head, and hand ports, especially for very high-pressure boilers**, as the seals tend to lose their elasticity due to permanent deformation from the crushing.




On seal caps gaskets, remember having the nuts/bolts “correct torque”, but also the “sequence”.

The hydraulic leak test simply involves venting the air through the atmospheric valve, supplying the boiler with water (even if it's warmer than normal, as long as there's no steam pressure) using the same feed pump until the operating pressure is reached.

The pressure is then regulated by adjusting the boiler's feed inlet or by turning the pump on and off (the pressure will not exceed the safety valves' setpoints).

**At this pressure, the boiler can be left in presurized as long as necessary to inspect for leaks or make adjustments, as it's within the boiler's authorized operating pressure range.**

**The hydraulic test, used to assess the strength of the boiler body, subjects it to high stresses. If these stresses are left unchecked for an unreasonable period or varied rapidly, they can cause permanent deformations or fatigue, which will be the future cause of potential accidents due to failure of the pressure vessel structure.**

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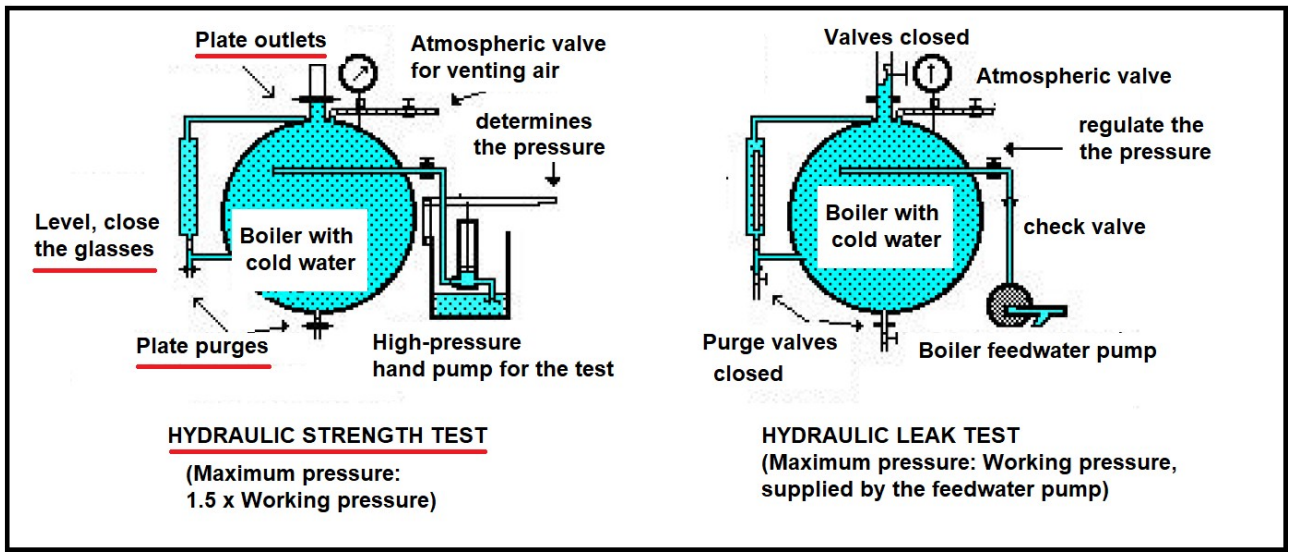
Due to the above concepts, before performing the hydraulic resistance test, due to its importance: determine the maximum test pressure, compare the test pressure gauge with a standard pressure gauge, verify that the air extraction valve does so completely, ensure the boiler is clean inside and out, properly plate it, clear the points to be observed, etc.




As a guide, the maximum recommended pressures for hydraulic resistance testing according to some codes are (although in Uruguay, the ASME code is used, which is 1.5 times the design pressure: that is, the maximum permissible working pressure).

Another standard recommends the use of the following values, which seem more appropriate (since it doesn't seem "reasonable" to test a boiler with a pressure of 1 kg/cm² at 1.5 kg/cm²).

The following is applied in some marine environments, where a boiler accident could be catastrophic.

***1. For boilers authorized up to 6.5 kg/cm² (92.4 PSI) working pressure, the pressure may be doubled during testing.***

***2. For boilers authorized between 6.5 kg/cm² and 13 kg/cm² (185 PSI), the test pressure may be up to 6.5 kg/cm² (92.4 PSI) higher than the authorized pressure.***

***3. For boilers authorized above 13 kg/cm² (185 PSI), the test pressure is 1.5 times the working pressure.***

**Generally, the test pressure is 1.5 times the maximum authorized working pressure, keeping in mind that very low pressure and high pressure boilers are subject to different values.** (The inspectors will determine the test pressure during official tests.)

**We must not overuse hydraulic strength tests** (since repeated hydraulic strength tests cause material aging: fatigue, so it is advisable that they be supervised by a qualified boiler technician).

**Increase and decrease the pressures slowly. Ensure that no abnormal deformation occurs as the pressure increases** (do not continue increasing the pressure if an abnormal deformation or noise is noticed: investigate, making sure that all air has been properly vented; or in case of deformation, stop the test and decrease the pressure).

If necessary, have measuring devices available beforehand in any "doubtful" areas: calibrated steel wires, measuring tapes, etc.

**Do not allow the maximum pressure to be maintained longer than necessary for visual inspection, deformation measurements, or pressure gauge readings.**

**Do not attempt to establish a higher hydraulic test pressure than specified for each case; this weakens the boiler in certain areas and could cause future failure.**

Take safety precautions when performing a hydraulic test. A rupture of a boiler part or the spontaneous perforation of a casing, cap, connection, etc., can cause a serious accident by projecting metal fragments or high-pressure water.

Although there will be no expansion because there is no air, there will always be dynamic pressure due to the elastic stretching of the boiler when subjected to pressure.

The old "peen hammer test" is practically obsolete. (Striking the suspected area with a ball-peen hammer to trigger a forced "rupture" if the material appears suspicious, with the boiler subjected to the hydraulic test pressure, is not a recommended

technique unless the person has extensive experience.)

**A hydrostatic test is not a guarantee of safety for a boiler.** (A boiler subjected to a hydrostatic stress test can suffer a breakdown within a few days of operation, such as a perforation in an area weakened by corrosion.)

Perhaps the explanation for this is that the boiler, under pressure when hot, experiences different stresses than when cold, or that the scale maintained its seal when cold but then detached due to thermal movements or the chemical treatment itself, etc.)

**Visual inspection, measurements, and inspections using equipment (thickness measurements, X-rays, ultrasound, etc.) are very important, but perhaps even more important is the experience of the technician performing the evaluation.**

Remember that a boiler is similar to an aircraft engine; if it has an accident, it is very difficult to predict its magnitude and exact timing. Therefore, maintenance and inspection schedules must be respected.

See the chapter on Structural Failures later for a guide to visual inspections.